

What is claimed is:

1. An apparatus comprising:
  2. an error filter coupled to an adaptive filter having N taps to filter a decision error provided by the adaptive filter using a leakage factor; and
    4. an updater coupled to the error filter and the adaptive filter to update N equalizer coefficients to the N taps using the filtered decision error, the updater receiving N equalizer data from the N taps.
  1. 2. The apparatus of claim 1 wherein the error filter is a high pass filter.
  1. 3. The apparatus of claim 1 wherein the error filter is a first-order high pass filter having a pole determined by the leakage factor.
  1. 4. The apparatus of claim 1 wherein the error filter has a zero at zero frequency.
  1. 5. The apparatus of claim 1 wherein the error filter comprises:
    2. a first computing element to compute an error difference of the decision error; and
      3. a second computing element coupled to the first computing element to generate the filtered decision error using the leakage factor.
  1. 6. The apparatus of claim 5 wherein the first computing element comprises:
    2. a delay element to delay the decision error; and
      3. a subtractor to subtract the delayed decision error from the decision error to provide the error difference.
  1. 7. The apparatus of claim 5 wherein the second computing element comprises:
    3. a delay element to delay the filtered decision error to provide a delayed output;
    4. a multiplier coupled to the delay element to multiply the leakage factor with the delayed output to generate a product; and

6           an adder coupled to the multiplier to add the error difference to the product to  
7 generate the filtered decision error.

1           8.       The apparatus of claim 1 wherein the updater comprises:  
2            N coefficient updaters coupled to the error filter to generate the updated equalizer  
3           coefficients using the N equalizer data and the filtered decision error.

1           9.       The apparatus of claim 8 wherein each of the N coefficient updaters  
2 comprises:  
3            a first multiplier to multiply a corresponding one of the equalizer data with the  
4           filtered decision error to provide a first product;  
5            a second multiplier coupled to the first multiplier to multiply the first product with  
6           an adaptive step size to provide a second product;  
7            a delay element to delay a corresponding one of the updated equalizer coefficients  
8           to provide a delayed coefficient; and  
9            a subtractor coupled to the second multiplier and the delay element to subtract the  
10          second product from the delayed coefficient, the subtractor providing the updated filtered  
11          coefficient.

1           10.      The apparatus of claim 6 wherein the delay element delays the decision  
2           error by one sample.

1           11.      The apparatus of claim 7 wherein the delay element delays the filtered  
2           decision error by one sample.

1           12.      A method comprising:  
2            filtering a decision error provided by an adaptive filter using a leakage factor, the  
3           adaptive filter having N taps; and  
4            updating N equalizer coefficients to the N taps using the filtered decision error by  
5           an updater, the updater receiving N equalizer data from the N taps.

1           13.    The method of claim 12 wherein filtering the decision error comprises  
2 filtering the decision error by a high pass filter.

3           14.    The method of claim 12 wherein filtering the decision error comprises  
4 filtering the decision error by a first-order high pass filter having a pole determined by the  
5 leakage factor.

1           15.    The method of claim 12 wherein filtering the decision error comprises  
2 filtering the decision error by a first-order high pass filter having a zero at zero frequency.

1           16.    The method of claim 12 wherein filtering the decision error further  
2 comprises:

3           computing an error difference of the decision error by a first computing element;  
4 and

5           generating the filtered decision error using the leakage factor.

1           17.    The method of claim 16 wherein computing the error difference  
2 comprises:  
3           delaying the decision error; and  
4           subtracting the delayed decision error from the decision error to provide the error  
5 difference.

1           18.    The method of claim 16 wherein generating the filtered decision error  
2 further comprises:

3           delaying the filtered decision error to provide a delayed output;  
4           multiplying the leakage factor with the delayed output to generate a product; and  
5           adding the error difference to the product to generate the filtered decision error.

1           19.    The method of claim 12 wherein updating the N equalizer coefficients to  
2 the N taps comprises:

3           generating the updated equalizer coefficients using the N equalizer data and the  
4        filtered decision error.

1           20.    The method of claim 19 wherein generating the updated equalizer  
2        coefficients comprises:

3               multiplying a corresponding one of the equalizer data with the filtered decision  
4        error to provide a first product;

5               multiplying the first product with an adaptive step size to provide a second  
6        product;

7               delaying a corresponding one of the updated equalizer coefficients to provide a  
8        delayed coefficient; and

9               subtracting the second product from the delayed coefficient to provide the updated  
10      filtered coefficient.

1           21.    The method of claim 17 wherein delaying the decision error comprises  
2        delaying the decision error by one sample.

1           22.    The method of claim 18 wherein delaying the decision error comprises  
2        delaying the filtered decision error by one sample.

1           23.    A computer program product comprising:

2               a machine useable medium having program code embedded therein, the program  
3        code comprising:

4               computer readable program code to filter a decision error provided by an  
5        adaptive filter using a leakage factor, the adaptive filter having N taps; and

6               computer readable program code to update N equalizer coefficients to the  
7        N taps using the filtered decision error by an updater, the updater receiving N equalizer  
8        data from the N taps.

1           24.    The computer program product of claim 23 wherein the computer readable  
2        program code to filter the decision error comprises computer readable program code to  
3        filter the decision error by a high pass filter.

1        25. The computer program product of claim 23 wherein the computer readable  
2 program code to filter the decision error comprises computer readable program code to  
3 filter the decision error by a first-order high pass filter having a pole determined by the  
4 leakage factor.

1        26. The computer program product of claim 23 wherein the computer readable  
2 program code to filter the decision error comprises computer readable program code to  
3 filter the decision error by a first-order high pass filter having a zero at zero frequency.

1        27. The computer program product of claim 23 wherein the computer readable  
2 program code to filter the decision error comprises:

3            computer readable program code to compute an error difference of the decision  
4 error; and

5            computer readable program code to generate the filtered decision error using the  
6 leakage factor.

1        28. The computer program product of claim 27 wherein the computer readable  
2 program code to compute the error difference comprises:

3            computer readable program code to delay the decision error; and

4            computer readable program code to subtract the delayed decision error from the  
5 decision error to provide the error difference.

1        29. The computer program product of claim 27 wherein the computer readable  
2 program code to generate the filtered decision error further comprises:

3            computer readable program code to delay the filtered decision error to provide a  
4 delayed output; and

5            computer readable program code to multiply the leakage factor with the delayed  
6 output to generate a product; and

7            computer readable program to add the error difference to the product to generate  
8 the filtered decision error.

1       30.    The computer program product of claim method of claim 23 wherein the  
2 computer readable program code to update the N equalizer coefficients to the N taps  
3 further comprises:

4            computer readable program code to generate the updated equalizer using the N  
5 equalizer data and the filtered decision error.

1       31.    The computer program product of claim 30 wherein the computer readable  
2 program to generate the updated equalizer coefficients comprises:

3            computer readable program code to multiply a corresponding one of the equalizer  
4 data with the filtered decision error to provide a first product;

5            computer readable program code to multiply the first product with an adaptive  
6 step size to provide a second product;

7            computer readable program code to delay a corresponding one of the updated  
8 equalizer coefficients to provide a delayed coefficient; and

9            computer readable program code to subtract the second product from the delayed  
10 coefficient to provide the updated filtered coefficient.

1       32.    The computer program product of claim 28 wherein the computer readable  
2 program code to delay the decision error comprises computer readable program code to  
3 delay the decision error by one sample.

1       33.    The computer program product of claim 29 wherein the computer readable  
2 program code to delay the decision error comprises computer readable program code to  
3 delay the filtered decision error by one sample.

1       34.    A system comprising:

2            an adaptive filter having N taps with N equalizer coefficients to generate an output  
3 sequence from an input signal, the adaptive filter generating an error decision; and

4            a tap-leakage generator coupled to the adaptive filter comprising:

5            an error filter coupled to an adaptive filter having N taps to filter the  
6 decision error using a leakage factor; and

7                   an updater coupled to the error filter and the adaptive filter to update N  
8                   equalizer coefficients to the N taps using the filtered decision error, the updater receiving  
9                   N equalizer data from the N taps.

1               35.    The system of claim 34 wherein the error filter is a high pass filter.

1               36.    The system of claim 34 wherein the error filter is a first-order high pass  
2                   filter having a pole determined by the leakage factor.

1               37.    The system of claim 34 wherein the error filter has a zero at zero  
2                   frequency.

1               38.    The system of claim 34 wherein the error filter comprises:  
2                   a first computing element to compute an error difference of the decision error; and  
3                   a second computing element coupled to the first computing element to generate  
4                   the filtered decision error using the leakage factor.

1               39.    The system of claim 38 wherein the first computing element comprises:  
2                   a delay element to delay the decision error; and  
3                   a subtractor to subtract the delayed decision error from the decision error to  
4                   provide the error difference.

1               40.    The system of claim 38 wherein the second computing element comprises:  
2                   a delay element to delay the filtered decision error to provide a delayed output;  
3                   a multiplier coupled to the delay element to multiply the leakage factor with the  
4                   delayed output to generate a product; and  
5                   an adder coupled to the multiplier to add the error difference to the product to  
6                   generate the filtered decision error.

1               41.    The system of claim 34 wherein the updater comprises:  
2                   N coefficient updaters coupled to the error filter to generate the updated equalizer  
3                   coefficients using the N equalizer data and the filtered decision error.

1           42.    The system of claim 41 wherein each of the N coefficient updaters  
2 comprises:

3                a first multiplier to multiply a corresponding one of the equalizer data with the  
4 filtered decision error to provide a first product;

5                a second multiplier coupled to the first multiplier to multiply the first product with  
6 an adaptive step size to provide a second product;

7                a delay element to delay a corresponding one of the updated equalizer coefficients  
8 to provide a delayed coefficient; and

9                a subtractor coupled to the second multiplier and the delay element to subtract the  
10 second product from the delayed coefficient, the subtractor providing the updated filtered  
11 coefficient.

1           43.    The system of claim 39 wherein the delay element delays the decision  
2 error by one sample.

1           44.    The system of claim 40 wherein the delay element delays the filtered  
2 decision error by one sample.